THE EXPLOSIVES ENGINEER

REG. U.S. PAT. OFF.

Forerunner of Progress in Mining, Quarrying, Construction

The record blast of 628,985 lb. of explosives recently detonated at the Peter Mitchell Mine of the Reserve Mining Company was not an effort to secure newspaper headlines. Rather, the size of the blast was dictated by the economic necessity of producing a large quantity of well-broken taconite at the lowest possible cost. Guided by studies of various size blasts at this property, the management decided a large blast would produce the results desired.

A detailed description of the reasons, the planning, execution, and results of the largest open-pit mine blast on record starts on page 167.

° ° °

With its steadily increasing population and accelerated industrial and agricultural demands for water, California, like most other states, is constantly searching for new sources of this vital commodity. To secure this much needed water, California has started the Trinity River Project. This project will tap lakes and rivers of the rugged Trinity County area which has long been known as an outdoorsman's paradise because of an abundance of fish and game.

One of the biggest jobs of the project will be the driving of the 11-mile-long, 20-ft.-diameter, concrete-lined Clear Creek Tunnel. For an interesting description of this region and the tunneling procedures, please turn to page 173 and read the article by Robert Lee Behme.

° ° °

With cities growing in all directions, many quarries that formerly were far removed from human habitation and could operate without disturbing neighbors are now receiving complaints about noise and vibrations from homeowners in ever-increasing numbers. It is interesting to read the account of the steps the Ready-Mix Concrete Company of Rome, Georgia, took to circumvent such complaints and at the same time increase blasting efficiency.

John Loviza's article "Blasting with Short-Period Delay Detonators in Georgia Limestone," which begins on page 179, details the blasting procedures and explains the results of the studies made to determine the vibrations and the noise levels caused by blasting.

° ° °

The Moles Awards for 1959 will be given to James F. Armstrong, vice president of Peter F. Connolly Company, and John Bruce Bonny, vice president and general manager of Morrison-Knudsen Company, Inc., for outstanding contributions to construction progress. More details will be found on page 184.

° ° °

With suitable ceremonies at widely separated parts of the country, the Sentinels of Safety trophies and flags were presented to five of the six winners of the 1957 National Safety Competition. Company officials, representatives of the U. S. Bureau of Mines, local officials, and guests paid tribute to the workers at the National Gypsum Company in Pennsylvania, Michigan Limestone Division of U. S. Steel in Michigan, Hanna Ore Mining Company in Minnesota, Tennessee Copper Company Division of Tennessee Corporation in Tennessee, and Republic Steel Company in Kentucky.

Brief descriptions of the ceremonies honoring the winners are given in the article on page 185.

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Views and opinions expressed by the authors of articles in this publication are their own, and they do not necessarily represent those of the publisher.

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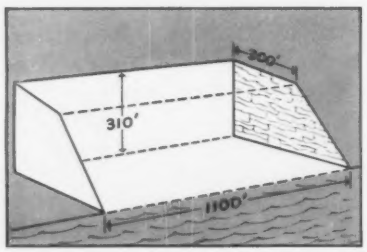
NIAGARA POWER PROJECT

Joy Challenger Drills Start Powerhouse Rock Job

Joy Challengers started drilling blastholes within 60 days after Merritt-Chapman & Scott was awarded the $99 million contract last February for construction of the main powerhouse of the Niagara Generating Plant at Lewistown, N. Y. The entire Niagara Power Project will cost $625,000,000.

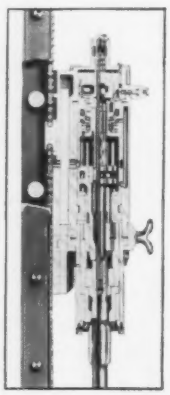
Here's the rock that must be moved



With 9,000,000 cubic yards of plant site rock to drill, M-C&S relies on Joy Challengers to get on with the CONSTRUCTION AHEAD. These Joy drifters drill 4" or 4½" diameter holes 30' deep without a steel change. Drill cycle speed and smooth operation proved Joy the best for the job.

Joy TM-500 Drills go deep

The guts of the Joy Challenger is the rugged 630 lb. TM-500, a 5¼" bore drill that combines power-packed punch and rotation with outstanding hole cleaning ability to bottom deep blastholes with ease. Features of the TM-500 include:



Force Feed Lubrication of all rotating parts.

Exclusive Joy Dual Valve for positive air control on up and down stroke of the piston.

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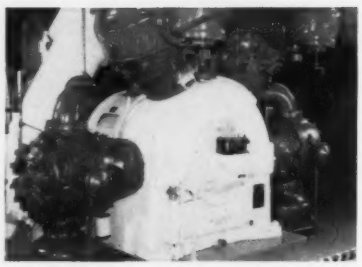

Joy WN-224's Supply the Air

Since M-C&S is using 5 Joy Challengers on the rock, three Joy semi-radial, four-cylinder WN-224 water cooled, two stage compressors are used for air requirements. The WN-224 is the largest package-type compressor available.

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7. **DOUBLE-PACKED WALLOP**—Bridge wire extends into the priming charge and makes positive contact to give rapid ignition.

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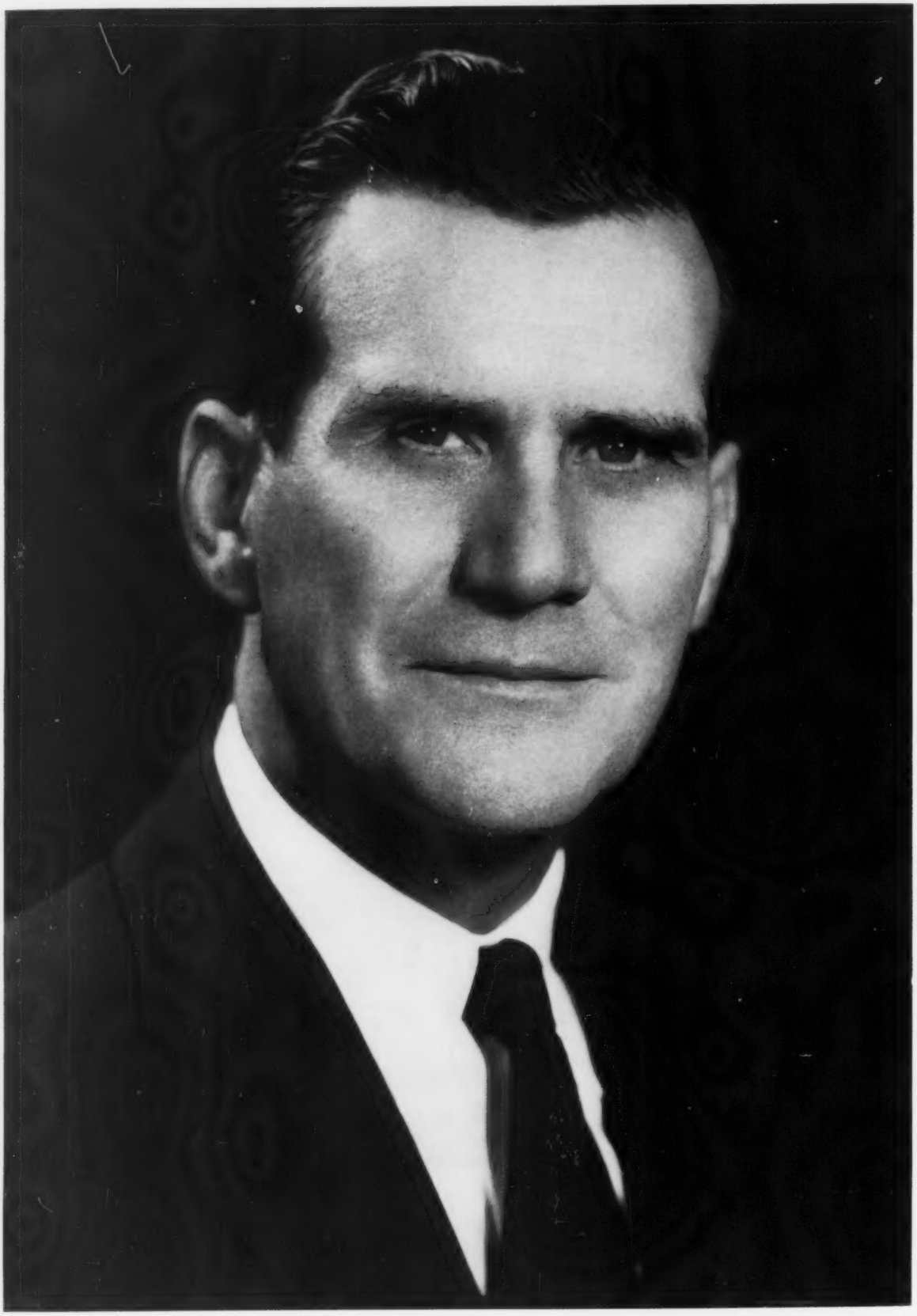


ROBERT J. LINNEY

Robert J. Linney

EXECUTIVE VICE PRESIDENT

RESERVE MINING COMPANY

A Biography

In 1940 Robert J. Linney decided to stop sliding downhill and begin climbing uphill in earnest. And with that decision bobsledding lost one of the greatest figures in the history of the American sport. At the same time the Republic Steel Corporation began to get the undivided attention of the mining engineer it had just appointed general superintendent of its Port Henry, New York, Division.

The holder of virtually every major North American title in this he-man sport, young Bob came by his taste for mining naturally—he represents the fourth consecutive generation of mining in his family.

Bob's grandfather was a Welsh miner who left the iron mines of England to emigrate to the United States. His father, Joseph Robert Linney, started as a slate picker in the coal mines near Scranton, Pennsylvania. Here he advanced rapidly until the Delaware & Hudson Coal Company offered him the post of manager of its northern iron-ore subsidiary, the Chateaugay Ore and Iron Company at Lyon Mountain, New York. The elder Linney changed this property from a raw, rough-and-tumble mining venture to a safe, efficient mining property.

Just as his father had started his mining career in the Pennsylvania coal fields at the age of ten, Bob began work at the age of twelve in the magnetite properties in the Adirondacks. He attended grade schools in Taylor, Pennsylvania, and in Lyon Mountain, and Worcester Academy, Worcester, Massachusetts. He studied engineering at Yale University, and in 1929 took his first full-time job as a mining engineer, returning to the same properties in New York State that his father had rebuilt, reorganized, and directed.

A year after he began work as a young engineer he was made level foreman. Three years later he became superintendent of concentrating and sintering, and in 1937, general manager. Shortly after the Republic Steel Corporation acquired these properties in 1939 he was made district manager at Lyon Mountain, New York.

This was the period when bobsledding shared his interests, and he was able to put his knowledge of engineering and metals to work in that sport. The energetic sledder not only changed some of the sledding techniques, but redesigned the bobsled itself. This, plus his drilling of the team for the starts and his skillful and fearless driving, won fame for Bob. He was the holder of the four-man North American title, the one-mile track record at Mount VanHoevenberg (the bobsled shrine of North America), and was nominated the No. 1 bobsled driver of 1939. With the choice by the Olympic Bobsled Committee of Bob's team to represent the United States in the 1940 Olympics, only the Olympic championship remained to be added to his laurels. Unfortunately, the team never had the chance to compete at Saint Moritz that year because of the war.

But his appointment in 1940 as general superintendent for Republic Steel at Port Henry, New York, spelled the end of bobsledding for Bob. He announced his retirement from the sport to devote his time to the new job. Ten years later Republic sent him to the Reserve Mining Company's taconite operations at Babbitt and Silver Bay, Minnesota, the new venture owned equally and jointly by Republic Steel Corporation and Armco Steel Corporation. As manager of operations, he had an important role in helping plan and design the vast facilities created for this pioneer effort in a field that hitherto had baffled every attempt by the iron-mining industry to solve the problems presented. In 1956 he was made vice president in charge of operations of Reserve and in July, 1958, he was made executive vice president, the position he now holds.

His share in the development of the taconite process was not solely as an executive, either. He holds patents used in mining, beneficiation, and agglomeration, including the Linney Magnetic Separator now used at Silver Bay. He is the author of numerous technical articles on mining, beneficiation, and agglomeration. With some thirty years' experience in the mining and processing of magnetite and taconite, Bob Linney now stands at or near the top in this most basic American industry.

Bob is a man of many interests. He is an avid baseball fan, and has played and managed amateur and semipro ball teams. He loves music, is a self-taught organist, and plays on occasion for his own relaxation. He and his wife, Jane, live at 71 Adams Boulevard, Silver Bay, Minnesota.

Mr. Linney has been active in community affairs: a former president of the Port Henry Chamber of Commerce, and of the Young Republican Club of Clinton County, New York.

He is an enthusiastic club man, maintaining club memberships in the cities he visits most frequently. He is also a member of the Lions, Elks, Shrine, and Theta Xi.

THE EXPLOSIVES ENGINEER ★ DEVOTED TO INCREASING EFFICIENCY AND SAFETY IN THE MINING, QUARRYING, AND CONSTRUCTION INDUSTRIES

The members of the editorial staff of THE EXPLOSIVES ENGINEER extend to their readers and friends throughout the world best wishes for the new year.

Editorial

Power of An Idea

The Sentinels of Safety trophy is a bronze statue of a mother holding her baby in her arms, the child holding his hand outstretched to welcome the father upon his safe return from work. The idea in the mind of the sculptor, Begni del Piatta, when he executed this statue was that the figures of the mother and child were sentinels standing at home keeping watch over the safety of the husband and father.

Every year since 1925, these six trophies have been put up for competition and annually presented to the winning mine or quarry. Necessarily, the competition is based upon statistics submitted periodically by each participating mine and quarry. The raw statistics and the computations made from them are vital to the success of the program. Without them, we would not know who were the winners and what the progress of safety has been throughout the years of the competition. But there is more to this competition than an admirable statistical record and it is that phase that we should not forget.

It seems almost unthinkable that men might not want to be safe. Too often, however, people look upon the safe way as more time-consuming, requiring more effort, and less exciting than the quick shortcut. Something is needed to make the heedless worker want to be safe.

It is the power of an idea that moves men to be safe and prompts them to adopt the safe practices that have saved life and limb. The symbol of a mother and child has been a powerful force for safety. These bronze figures symbolize the miner's dearest possessions, and we believe they have become so firmly implanted in the minds of the quarrymen and miners that they recall their homes and families at the critical moment. The symbol has achieved its purpose when it influences that split-second decision—whether to take a chance or to take time to be safe.

A mine inspector once recalled to us the last moments of a miner dying of injuries sustained in a mine accident. The dying miner, going over his life and realizing that it was finished and could no longer be changed, told the inspector he had but one regret: that he had not shown more kindness and consideration to his wife. That anecdote illustrates the power of the Sentinels of Safety symbol.

Record Without Equal

The Bureau of Explosives of the Association of American Railroads has reported that the year 1957 was again a year in which no one was killed or injured in the rail transportation of Class A commercial explosives. This was the 36th consecutive year in which no deaths occurred in this potentially hazardous activity. This remarkable record of safe transportation deserves our unstinted praise for a job well done.

Records that occur regularly year after year are apt to seem routine and commonplace, and attract little notice. Often the public is more than a little inclined to feel that these years of no accidents "just happen." But we need only look at the record of the transportation of explosives in some other countries, and it becomes plain that explosions can and do happen on railroads, and that the life and property losses are colossal. Accidents may just happen, but a long-continued, unblemished safety record takes a lot of doing.

The report of the bureau recounts the history of this effort since its inception in 1905. Through the years, the yearly tonnage of explosives shipped has more than doubled. The bureau, originally established to cover only explosives, was expanded to include flammable liquids and solids, oxidizing materials, corrosive liquids, compressed gases, poisons, and radioactive materials. In fact, the list of dangerous articles in transportation, which stood at 184 in 1922, now includes approximately 1,300 items. "The tonnages of many of these individual items presently being shipped far exceeds the quantities transported in previous years, yet there has been no corresponding increase in loss of life resulting from their transportation, and the nominal increase in property loss that has been experienced has been due to inflationary conditions rather than any increase in actual loss," says the report.

The bureau recounts the activities of its people over the year in inspecting explosives, and containers made for their shipment, their assistance in the development of satisfactory containers and ways of blocking and bracing these dangerous articles for transportation. Conferences were held with shippers and container manufacturers, and inspections made of railroad stations and yards. New explosives and devices, such as solid and liquid propellant fuels, and initiating, control, and release devices, were examined, tested, and approved.

Truly this is a record of cooperation between all concerned in the transportation of dangerous articles on the railroads of the nation. It is a remarkable record of care, of painstaking progress, and of infinite patience devoted to the one end: the protection of life and property through the safe transportation of dangerous articles. The bureau richly deserves our thanks.

MILLION-TON BLAST: The nation's largest mining blast at the Peter Mitchell Mine shows an unusual columnar shape.

Largest Open-Pit Blast On Record

Reserve Mining Company cuts cost of mining and milling as 628,985 lb. of explosives bring down 1,140,135 long tons of taconite

WILLIS E. RANSOM*

THE Peter Mitchell Mine of the Reserve Mining Company lies at the easternmost end of the Mesabi Iron Range and consists of low-grade magnetic taconite. The mineral deposit is 9 miles long, an average of 2,800 ft. wide, and 175 ft. deep at the thickest part of its wedge-shaped cross section. The estimated reserves in this area are 1½ billion tons of magnetic taconite averaging 24.19% magnetic iron, probably enough to keep the Reserve Mining Company going at its present rate for over 100 years.

This taconite has lain in the Minnesota hills throughout the decades that the American iron-mining industry has wrested iron ore from the Mesabi Range, and the vast stretches of hard, flinty, low-grade material, estimated to run into the billions of tons, have been despised and largely ignored by the miners seeking food for America's blast furnaces to the south. A few voices, notably that of E. W. Davis, then a professor at the University of Minnesota, prophesied that some day taconite would come into its own and become our primary source of iron ore for steelmaking. The steel industry for almost a century has recognized the

*Hercules Powder Company
Duluth, Minnesota

vast reserves of ore in the taconite deposits, containing enough to supply the nation's mills for many years to come, but they ruefully shook their heads over the problems involved in wresting that iron content from this hard, almost diamond-like rock. In the main, taconite was by-passed in the search for rich ores requiring less milling.

Last August 25, however, the Reserve Mining Company at Babbitt, Minnesota, detonated a blast that was epoch-making for several reasons. It was, for one thing, the largest open-pit blast in the history of the iron ranges. This blast consumed 628,985 lb. of explosives in bringing down 1,140,135 long tons of taconite. Yet this blast was spectacular in other, and more significant, ways.

Dr. Davis, now retired from his post at the University of Minnesota, a spectator at the blast, declared afterward that the magnitude of the blast is the most significant development in the progress in iron mining since the principles of taconite concentration were developed in the laboratories of the University of Minnesota.

Unique Jet-Piercer Succeeds

The difficulties in the way of the successful mining of taconite, however, appeared to be almost insurmountable. First of all, it is a low-grade material, running around 25% iron content, the tiny iron-ore particles sprinkled through the rock. It is so hard, one of the hardest rocks known, that conventional drills, such as those ordinarily used on the iron ranges, were almost useless against it. The best drills could put down holes at only 1 ft. an hour, making drilling costs prohibitive. This obstacle, however, was overcome with the development of the jet-piercer, a rotating flame thrower that "burned" holes in the rock.

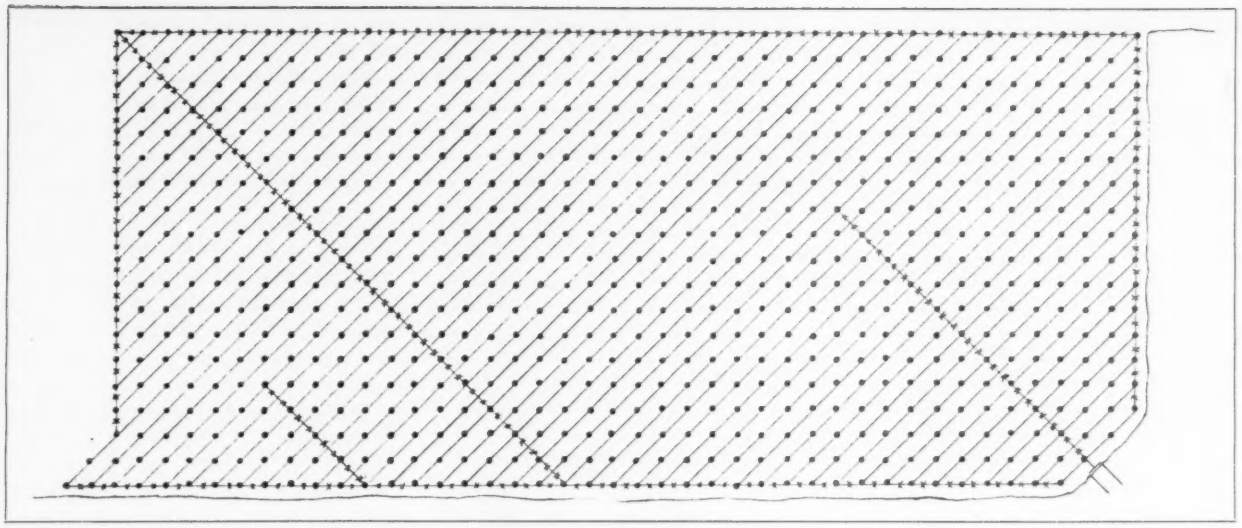
To produce the blast hole, jet piercing utilizes thermal energy. It is a complicated flame thrower that produces a tailored flame by a rocket-type triple-orifice burner. It burns liquid oxygen and fuel oil and creates heat of 4300°F. The flame strikes the rock and the intense heat causes a thin surface layer to expand and break away as a result of thermally induced stresses. The action of the jets blows the spalled rock out of the path of the flame and exposes fresh surface to the flame. Fusion will occur in broken rock or where the iron band is thick, but depth of melt is shallow and is blown away, quenched and embrittled by the steam and water, or broken up if necessary by the hole sizer and easily ejected. Water acts as a coolant and preserves the combustion chamber, being discharged near the bottom of the hole where it quenches and embrittles any material that may have been fused by flame. The waste heat in the combustion produces steam from a large portion of the water, which aids in ejecting the spallings continuously from the hole.

The jet-piercing machine, mounted on a crawler-type tractor, is equipped with a 64-ft. mast from which is suspended a 55-ft. blow pipe. The blow pipe consists of a swing joint, kelly, and burner assembly. Oxygen, water, and fuel oil are introduced into the rotating blow pipe through the swing joint. The kelly is a round triple-fluted pipe, which is rotated by an 18-in. turntable located approximately 3 ft. above the ground. Oxygen and fuel oil are carried through different-diameter tubes on the inside bore of the kelly to the burner assembly. Water is brought to the burner in the remaining space inside the kelly.

For safety, the gas- and steam-removal system has been isolated from the main cab to prevent fume leakage into the machine. The cab also has been sealed against fumes, and fresh

LOADING: A 35-lb. cartridge of semigelatin dynamite primed with an XC-45 booster and wire-countered Primacord is lowered into the hole.

TNT: Pouring E. P. 158 pelletized TNT to fill the voids around the semigelatin cartridges in the bottom chamber.



DRILLING PATTERN: Sketch of the largest open-pit blast in the history of the iron ranges, at the Peter Mitchell Mine, Babbitt, Minnesota, fired August 25. Crosses indicate 17-millisecond connectors. The lower and right-hand sides were open faces, and the point of initiation is indicated in lower right-hand corner.

air is brought into the cab through a pipe from high on the mast. Electro-mechanical interlocks shut off the burner flame instantly if there is waterflow failure. Oxygen flow through the blow pipe cannot be initiated without water flowing at a rate above a safe minimum. Fuel and oxygen piping and hose are of different size in order to prevent interconnecting of the two lines.

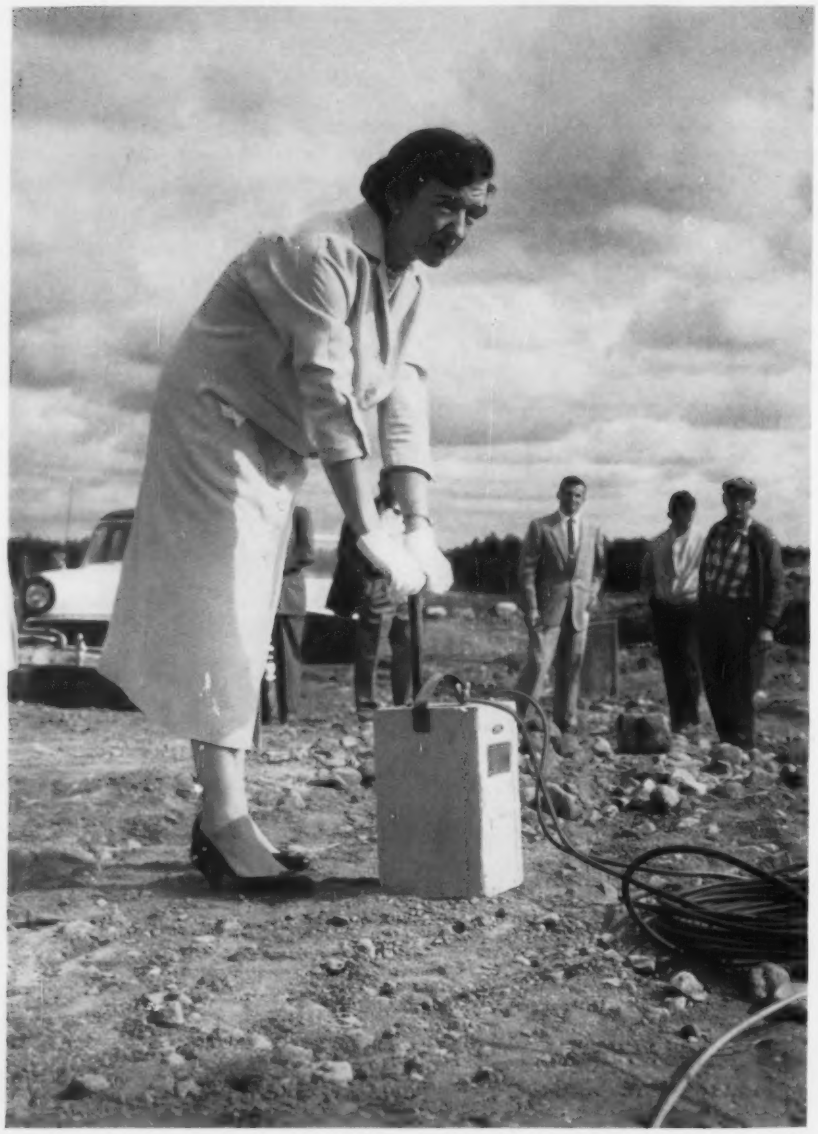
Taconite is hard and spallable, which makes it possible for a piercing machine to burn a 6¾-in.-minimum-diameter hole at the rate of as high as 35 ft. per hour to a maximum depth of 50 ft. A hole may be enlarged or chambered with ease at any point where it may be desired to concentrate more explosives. The rate of penetration varies because drilling must be done where blasting has produced backbreak, through bedding and joint planes, and, also, because the rock is not uniform but is made up of alternate bands, rich in magnetite, or in silica.

All blast holes for the big blast were put down with Linde-Air jet-piercers produced by Bucyrus-Erie using 6¾-in. hole sizers. The overall average per piercer was 133 ft. of hole per shift, or 16.63 ft. per hour. Thorough cleaning of the rock surface during stripping operations has made it possible to increase burning time of all piercers to 82%.

Oxygen was used at the rate of 550 cu. ft. per foot of hole and was delivered to the piercers in cascade trailers having a capacity of 70,000 cu. ft., sufficient for one operating shift. Fuel oil consumption was at the rate of 2 gal. per foot of hole. Water was delivered to the piercers by water trucks and pumped into 4,800-gal. water wagons, one per piercer. These water wagons are insulated and equipped with immersion heaters for winter operations. Water was consumed at the rate of 1,000 gal. per burning hour.

Primary drilling requirements for Reserve's 15,000,000-ton-per-year taconite operation are handled by four jet-piercing machines operating 20 shifts per week. Labor requirements are 11

STEMMING: Spalled fragments from the jet-piercing operation were used to stem the top 4 ft. of the blast holes.



TRIBUTE TO MINERS' WIVES: Mrs. Robert J. Linney, wife of the executive vice president of Reserve, fired the big blast as a tribute to the wives of the Reserve employes, who have given their husbands encouragement and support, and who have shown patience and understanding to their men as they pioneered the new industry.

men per shift, including two-man operating crews per machine and for hauling oxygen, fuel oil, and water. A six-man maintenance crew works the day shift, seven shifts per week.

While development of the jet-piercer reduced the drilling problem in taconite, other problems remained for its successful mining and milling. Excavating, loading, hauling, and crushing costs were excessive, compared with that of the usual magnetite ore on the range. Early in the taconite operation, fragmentation and pulverization were poor. Extensive secondary blasting was required to load and crush it. Wear and tear on the equipment was high because of the size of the chunks. Better fragmentation was needed to cut down the load on the crusher. To this end, experiments were tried to determine an effective drilling and blasting pattern. At first, two rows of holes at 19-ft. intervals were used. Results were poor. Three rows were tried, and then a single row. Backbreak was excessive in two- and three-row blasts, slowing down the drilling rate; hence single-row blasts were settled upon as the pattern.

One factor contributing to poor fragmentation was the pronounced bedding and joint planes at or near the surface, planes of weakness along which the rock tends to break into large tabular blocks that rode out unbroken on top of the blast. To help eliminate this problem small 1½-in. satellite holes were pierced around the large blast holes. These holes were loaded, tied in, and shot with the main blast.

When production requirements at the mine were increased from 1,000,000 tons a year to 15,000,000 tons in 1956, however, single-row blasts with the resulting low muck piles, and frequent moving out of equipment with its attendant lost time, required a new drilling and blasting pattern.

New Drilling System

To meet these greatly increased demands for ore a completely new drilling system was put into practice. Box cuts at about 2,400-ft. intervals were developed along the sides of the initial or development cut. Mining then proceeds from one box cut to the next, parallel to the development cut. This then allows the blasts to relieve in a direction where bedding planes have no adverse effect in breaking to grade. The best fragmentation results when firing a minimum of ten rows. The holes are drilled on a square pattern parallel to the long face, 3 ft. below grade and the bottom 4 ft. are double chambered. Double chambering is accomplished by making two extra passes with the jet-piercer at the rate of 6 in. per minute. This provides greater explosive density for breakage of the rock at the toe or to grade. The multiple-row pattern has minimized backbreak, thereby reducing fractured material in areas to be drilled for succeeding blasts.

For the big blast of August 25, drilling began in March, 1958. Holes were laid out by field engineers under the supervision of the engineering department of Reserve. The area blasted, 7.1 acres, was pierced with a total of 794 holes 6½ in. in diameter set out in a quadrangle 19 rows each 360 ft. wide, and 42 rows each 860 ft. long. The

total footage put down by jet-piercers was 30,897 ft. or 5.9 miles of holes. The blast was laid out on a 20 by 20-ft. square pattern with average depth of 38.9 ft.

Loading the Explosives

Piercing was completed on July 24, and loading began immediately, and continued, except for one week when the entire operation was down, until the day of the blast. The explosives used were semigelatin dynamite, pelletized TNT, and prilled ammonium nitrate. Wet holes were loaded differently from dry holes, no prills being used in the wet holes.

The bottom 4 ft. of all holes was chambered. The loading of a hole was started by punch-priming a 6-in. by 35-lb. tapered-end cartridge of E. P. 152 semigelatin with an XC-45 booster and wire-countered Primacord.* The blaster lowered the primed cartridge to the bottom of the hole on a rope, and then one 50-lb. box of E. P. 158 pelletized TNT was poured into the hole to fill the void around the 6-in. cartridge of semigelatin. Another 35-lb. semigelatin cartridge was lowered on top of the first and another 50-lb. box of TNT was poured around it. This was continued until six semigelatin cartridges had been lowered into the hole and four 50-lb. boxes of TNT had been poured around them. By this method, additional explosives were concentrated in the bottom of the hole. The blaster kept a check on the height of the column by placing a clothespin on the rope and checking as he lowered each cartridge into the hole. This loading in the chamber permitted the bottom 4 ft. to be loaded with a powder factor of 1.68 lb. per ton, and the remainder of the hole was then loaded to maintain an *overall* factor of 0.35 lb. per ton.

All holes were loaded in the chamber in this fashion. Above this point, loading depended upon the wetness of the hole. In wet holes loading continued with semigelatin using E. P. 152 5½-in. by 30-lb. cartridges, the average hole taking 12 more cartridges totaling 360 lb. The load was brought up to within 4 ft. of the collar of the hole. The last cartridge to be loaded into the hole was punch-primed with an XC-45 booster and wire-countered Primacord. The explosives in the wet holes totaled

*Reg. U. S. Pat. Off. by The Ensign-Bickford Company

FRAGMENTATION: This view, taken shortly after the blast, shows the fragmentation obtained in the taconite and the absence of backbreak.

770 lb., consisting of 570 lb. of semigelatin and 200 lb. of TNT.

There were 203 holes which were dry and were loaded with ammonium nitrate prills. A 25-lb. bag of ammonium nitrate chunks, E. P. 201-L, was first poured on the top cartridge in the chamber load to seal off the hole and prevent the prills from sifting through into water that might have collected at the bottom of the hole.

To load the prills four 50-lb. bags were poured into the hole and then 2½ gal. of fuel oil, and this procedure repeated until the hole was loaded to within 4 ft. of the collar. A top primer cartridge of semigelatin, E. P. 152, 4 in. by 15 lb., was punch-primed with an XC-45 booster and wire-countered plastic Primacord and lowered into the hole near the top of the column and covered with a foot or two of prills. The remainder of the hole was stemmed with drill cuttings from the surface near the hole collar. The explosives and blasting agents in the dry holes totaled 920 lb., consisting of 225 lb. of semigelatin, 200 lb. of pelletized TNT, 25 lb. of ammonium nitrate chunks, and 470 lb. of prills.

The total explosives and blasting agents used in this record open-pit shot was:

E. P. 152 semigelatin	369,010 lb.
E. P. 158 pelletized TNT	159,250 lb.
E. P. 201-L ammonium nitrate chunks	5,075 lb.
Prills	95,650 lb.
Total	628,985 lb.

Controlled Blasting

The fly rock that results from this method of loading a hole would be a problem in a confined area. The fly from the million-ton blast, however, was less than from smaller blasts; very little fly was found beyond 500 ft. Equipment was moved out of the blasting area approximately 1,500 ft., and manpower approximately 3,500 ft. At Babbitt, the time lost in moving equipment and men out of the area is not great since the number of blasts per month are few; but, obviously, the larger the blast the more tonnage that is obtained with each move of men and equipment.

As the blast was a corner-block location having two open faces roughly at right angles to each other, a diagonal tie-in pattern with 17-millisecond Primacord connectors for each interval was used. The loading made use of 57 delay periods, making a total elapsed time of 0.97 seconds for the detonation. This pattern produces a safe, low-working bank and excellent fragmentation.

The new drilling-and-blasting pattern has produced the results that were hoped for. Experience indicates that the larger the blast, the better the fragmentation. In fact, fragmentation on the big blast of August 25 reached an average of 99% usable fragments, leaving less than 1% for secondary work. Over 50% of all broken rock is minus 3½ in. in size. With results such as this, half of the ore can be screened and shipped direct to Silver Bay, thus doubling the throughput of the crusher.

This fragmentation has increased the life of the shovel buckets 300% between rebuilds, the life of the dipper teeth from 12,000 tons per set to 31,000 tons per set. The loading efficiency of the shovels has improved 91%. The life of the concaves and mantle in the primary crusher has improved 70%.

Progressively larger and larger blasts had been shot before the August 25 blast, which was designed to bring down more than a million long tons of ore.

The million-ton blast is the final development in a succession of steps forward in the solution of the utilization of taconite. Considering the vast reserves of this material, the billions of tons readily available in Minnesota, the significance of the results obtained by the Reserve Mining Company at Babbitt on August 25 is far-reaching for the American iron and steel industry.

Editor's Note: Much of the material for this article was obtained from a paper presented at the American Mining Congress in San Francisco, September, 1958, by a mining engineer from Reserve Mining Company.

JOB FOREMEN: Blasting foremen for the job were, left to right, Martin Starkovich, Michael Evenocheck, and Michael Pavlovich.

Driving the Clear Creek Tunnel

The 20-foot-diameter tunnel, one of the major parts of the Trinity River Project, will be nearly 11 miles long when completed

ROBERT LEE BEHME*

SINCE man first explored it, in 1830, word of mouth has kept California's rangy, rugged Trinity County the State's top-rated hunting paradise. Rich with the history of early-California gold seekers, snow-capped mountains that once echoed to the hammers of the 49'ers now tower silently over forests filled with animals—deer, bear, mountain lions, and game birds. Along the mountain slopes some of the West's biggest trout work toward lowland streams.

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Los Angeles, California

For numberless years this has been California's most rugged frontier—a lush, heavily forested land rich in mineral and water. It is because of the water that the face of the land is now changing. By 1963 there will be five gigantic dams, four hydroelectric plants, several new highways and bridges, a fish hatchery, and five man-made lakes.

Although these will change the Trinity area, they will not alter its way of life. There will be new hunting lands to replace lands to be buried under acres of new lakes, just as there will be new camping grounds and new recreation areas. Recreation and conservation experts predict that these changes

INTAKE HEADING: Progress on headings has been rapid, averaging 40 to 50 ft. per day despite the fact that geological surveys were unable to accurately forecast exact conditions to be met along the line of the tunnel.

will spur a new popularity at Trinity.

Vast Project

Although an estimated $225 million will be spent to change the Trinity country, the improvements in recreation are but a part of the basic idea. The scope is much larger. The Trinity development is part of the United States Bureau of Reclamation's gigantic California Central Valley Project, a staggering agricultural reorganization that will eventually reroute northern California water throughout the State, now speeding badly needed irrigation water to the dry lands near Sacramento and Fresno, and, later, to feed drinking water to Los Angeles, 200 miles farther south. In addition, it will furnish an influx of new hydroelectric power for the entire West.

From any angle, the heart of the Trinity dream is water, and the water comes from the Trinity River. Now little used, it will soon find a useful route. It will be first stored in the 2,500,000-acre-foot Trinity Reservoir behind the yet-to-be-completed Trinity Dam. When it is finished, in 1963, the dam will be the world's largest earth-filled dam.

Water released from this reservoir will be utilized by a 96,000-kw. power plant at the Trinity Dam. Then it will be regulated in the Lewiston Reservoir, about 7 miles downstream, close to the small mountain town of Lewiston. The Lewiston Dam will route the water through a series of outlets, immediately releasing enough to meet downstream needs, including those of the $1,350,000 fish hatchery that will be built close to the downstream side of the dam.

The unused water will be diverted through the Clear Creek Tunnel. Flowing under the rocky slopes of the Buckhorn Mountains, this water will reach a 130,000-kw. power plant on Clear Creek, a tributary of the Sacramento River, some 11 miles south of Lewiston.

From this point, the water will flow into the 250,000-acre-foot Whiskeytown Reservoir on Clear Creek. There, the surplus passes through adjacent creeks, such as Spring Creek, to the 71,500-kw. power plant at Spring Creek and on to Keswick Reservoir on the Sacramento River. Experts now claim this network will yield 1,422,000 acre-feet of water per year—enough to be of major importance to busy farm lands south of Sacramento.

DRILLING AT THE FACE: The three-tiered jumbo is equipped with Gardner-Denver Model 93 waterliners mounted on hydraulic jibs. Here is shown a closeup of the lower drilling platforms as the crew is about to start a new heading.

Clear Creek Tunnel

One of the biggest jobs on the Trinity River Project is the Clear Creek Tunnel. When completed, the tunnel will be close to 11 miles long, 20 ft. in diameter, and concrete-lined throughout its length.

The contract for the tunnel excavation and lining was awarded to Shea-Kaiser-Morrison—a firm composed of The Shea Company, Henry J. Kaiser, Morrison-Knudsen Company, Macco Corporation, and the Raymond Concrete Pile Company. SKM began work in April, 1957, and the scheduled completion date is April, 1961. In the meantime, SKM crews face 11 miles of tunnel, approximately 700,000 cu. yd. of solid rock excavation, minimal 9-in. concrete lining for the entire length, construction of the intake structure, and excavation and lining of the surge chamber.

Rock of Unknown Quality

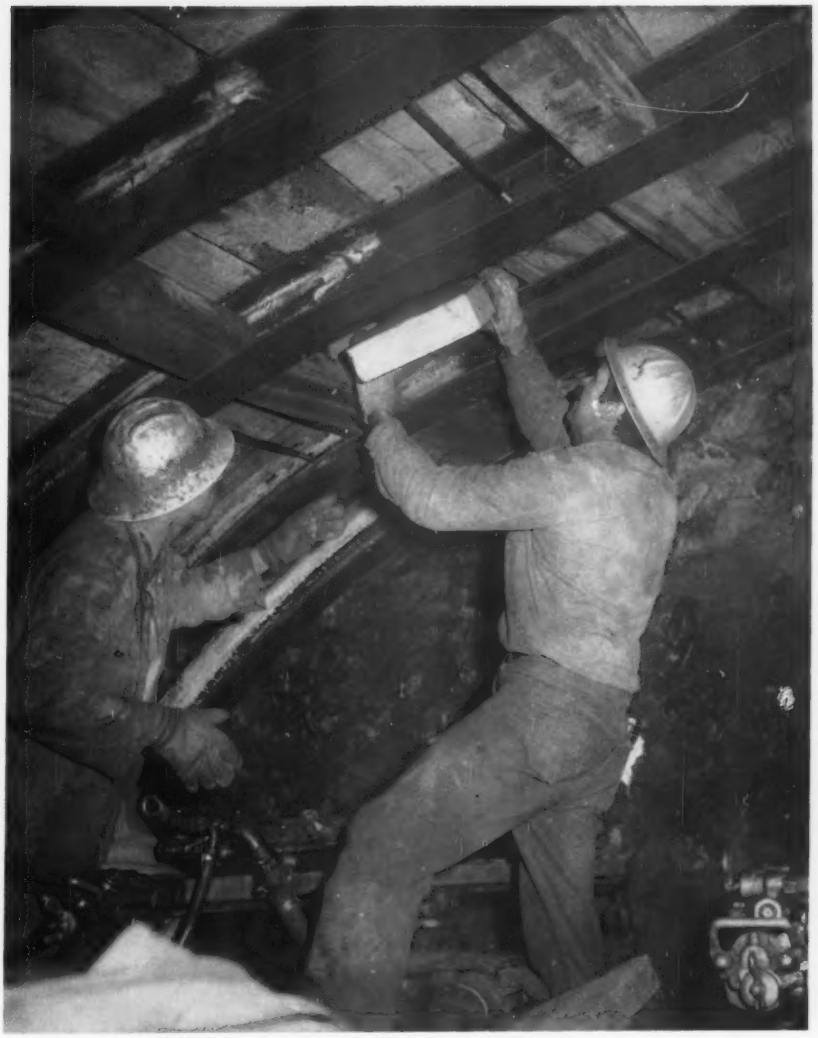
Although work has been moving steadily, often ahead of schedule, at the rate of 40 to 50 ft. per day on all headings, the progress is amazing because the job has been without precedent in Trinity. Even the initial bidding was unprecedented because of the unknown quality of the rock through which the tunnel was to go. The general structure—quartz diorite (85%), and bragdon (5%), and meta-andesite (10%)—was known, but there had been no large tunnels in the Trinity area before the Clear Creek job. Even the geological surveys were unable to accurately forecast exact tunnel conditions.

The uncertainty meant that SKM crews were faced with a "take what you find" job from the beginning. To minimize the unknown, SKM set up field offices close to both ends of the tunnel. In the high Trinity Mountains shipments from one point to another are not easily arranged. The inlet of the tunnel is about 42 highway miles from Redding, the nearest railhead, while the outlet is but 11 miles northeast of Redding. This great transportation differential on an 11-mile tunnel is accounted for by the twisting, back-tracking highway that links Lewiston to Redding.

The main SKM field office is housed in a large Quonset hut, off the main highway, a short distance from the outlet. A secondary office has been set up at Lewiston. It has complete facilities including repair shops, rail lines, hospital, lumber mill, welding shop, supply room, and field offices. The unit is fitted into a flat section of land cut into the side of the mountain, on the banks of the roaring Trinity River.

Outlet Started First

Work was first begun on the outlet, and in order to speed up the operation an adit approximately 800 ft. in area was driven 2½ miles from the actual outlet. The adit and some 750 sq. ft. upstream and downstream were excavated with a truck jumbo, Dumpys, and an Eimco #105 overhead loader.



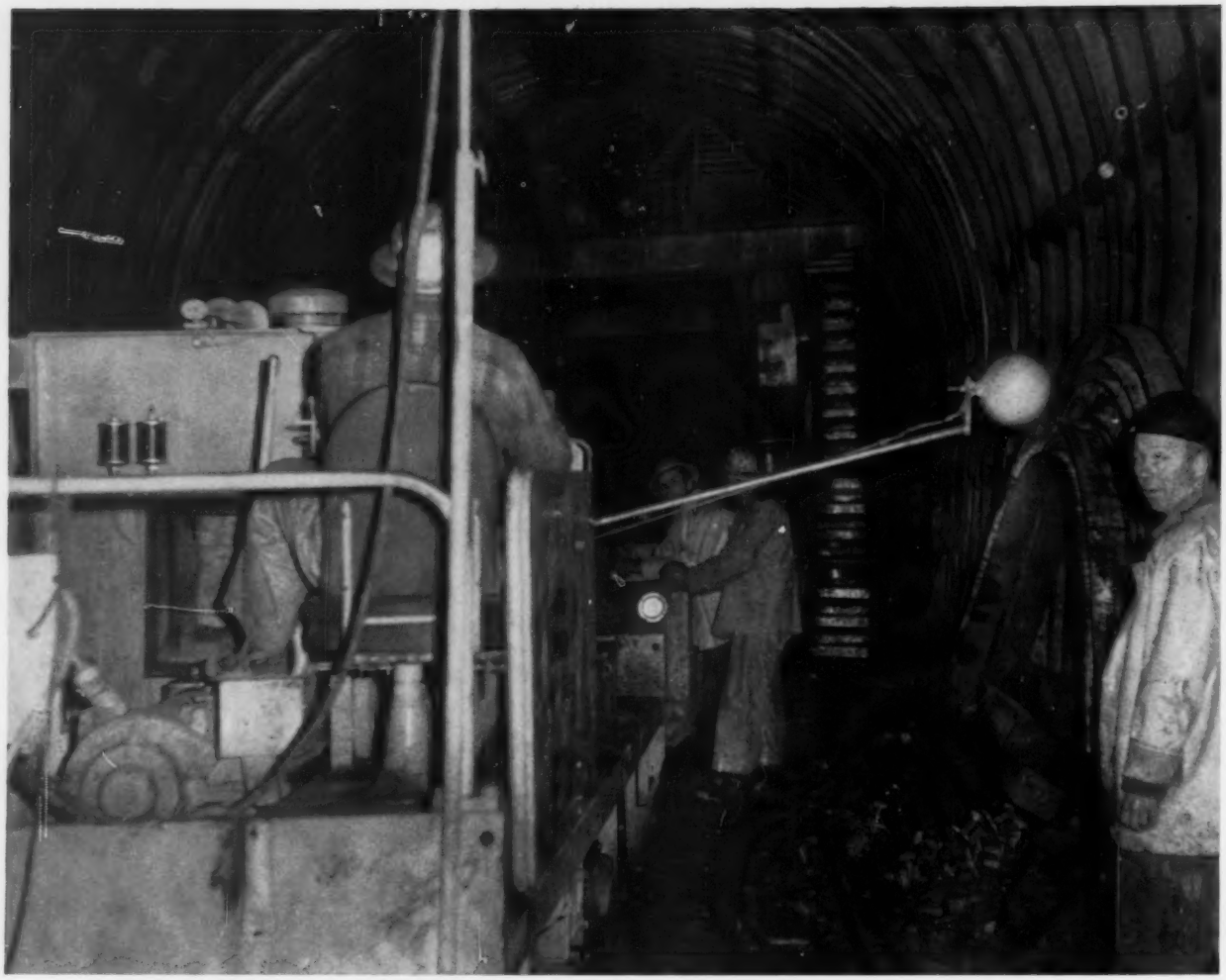
EXTRA SUPPORT: When auxiliary boarding is necessary, and it frequently has been because of the faulty nature of the rock, it is installed before resuming work at the heading. This protects the drilling crew from injury from falling rock.

SKM crews found this method of penetration was extremely effective up to a distance of 3,000 ft., and it was used at the outlet as well.

With the completion of the primary excavations at the outlet portion, SKM changed to a more conventional method of excavation on all headings. Even under conventional operations, the methods had to be varied to meet the conditions.

The first 6,000 ft. of the upstream adit proved to be very hard and solid rock. Later, a decomposed granite was encountered with little overburden. In this area, the ground had a tendency to squeeze and take weight. The steel supports, used to edge the tunnel, had to be changed. A heavier steel (8 in.) supporting was designed to counteract this. In general, the rock is a quartz diorite which made it necessary to drive a top heading and solid breast boarding in most of the softer sections. Here, three crews average about 48 ft. per day.

At the outlet, the rock up to about 5,000 ft. has been very soft and supplies no structural support. SKM again took precautionary steps such as breast boarding to save the heading. Structural steel has been used in this area, with an average spacing of 3-ft. centers. Rock has proved variable: 300 ft.



SAFETY FIRST: To avoid any stray current which might cause a premature blast, the electrical current is turned off during loading operations. Illumination at the face is then supplied by auxiliary lights mounted on and powered by a Plymouth Diesel locomotive.

Royalite; 1,500 ft. diorite; 800 ft. gneissic zone. The heading is carried forward at the rate of about 32 ft. per day on three shifts. All headings have worked three shifts.

The intake also proved to have a variable formation. A soft, block greenstone was encountered for the first 3,000 ft., necessitating a lot of steel support. A soft, finely fractured bragdon was encountered next, and this area had no structural support or stability. Tightly spaced supports, on 2- or 3-ft. centers, were needed, especially in a badly faulted 400-ft. section. Occasionally it has been necessary to drive a top heading and breast boarding, and to fit solid spile to prevent caving. Past this section crews found the quartz-diorite formations again. Here the section was hard and tight. Fewer structural supports were required and those used were fitted on wider centers. The formations are as follows: 300 ft. metaandesite; 4,000 ft. bragdon; 1,000 ft. gneissic zone; and the remainder quartz-diorite. Average progress here is 40 ft. a day.

Working Two Headings

Work has been reduced to two headings now, with a typical work cycle being the one used on the intake tunnel under the direction of Harry Greshuk, superintendent. Here, a work cycle begins as the gantry jumbo, equipped with cherry pickers and seven waterliners with hydraulic jibs, moves over special rails to the face. Drilling rigs, Gardner-Denver Model 93 waterliners with hydraulic jibs, are pushed out to the face from two platform levels and drilling crews prepare the shot holes. In cases where the face is brittle, drillers will work off loose sections of the facing before making the holes. Crews use Joy 1¼-in.-round drill steel and 1¾- or 1⅞-in. detachable Cormant bits.

The air is piped into the tunnel from Westinghouse Model XLE air compressors outside the tunnel. These have an 850-cu.-ft.-per-minute capacity and supply 100- to 120-lb. pressure with complete safety. Generally, the crews drill 1⅞-in. holes at depths between 4 and 8 ft. on 2-ft. centers.

When the drilling is completed, the rigs are folded back to the jumbo and a 12- or 15-ton Plymouth Diesel motor,

equipped with scrubbers, pulls the jumbo back from the face. A separate explosives car then moves to the face, all electric current is turned off, and explosives crews load the heading.

Typical Tunnel Round

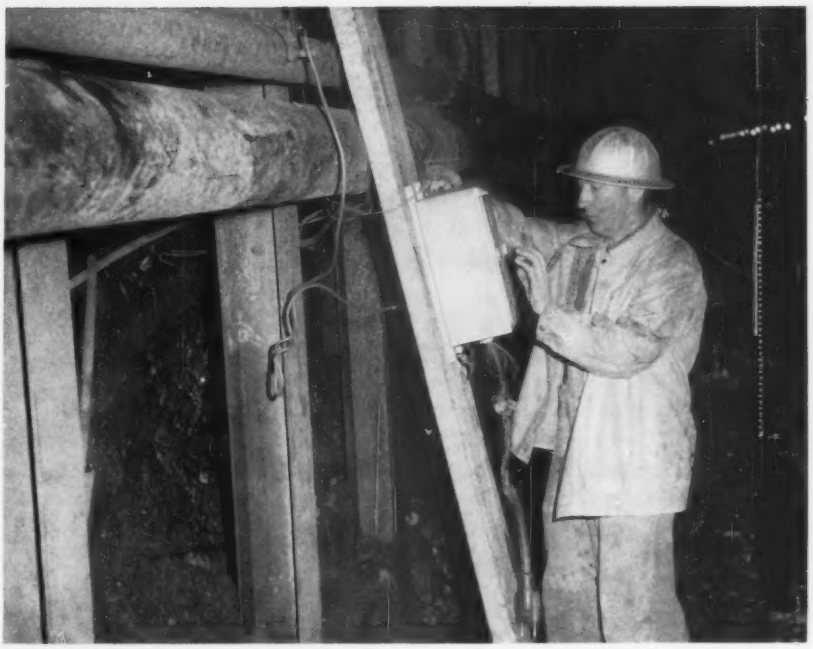
SKM uses 60% gelatin dynamite and Gelamite® 2, with 60% gelatin for primers. Two lengths of dynamite cartridges are used: 8 by 1⅛-in. primers and 12 by 1½-in. for Gelamite 2. The charge is placed in the bore holes by the explosives crew under the supervision of either the tunnel superintendent or the walker. On an average 8-ft. round, there are ten cartridges of explosives in each lifter hole, while the relievers contain four cartridges. These are tamped after each two cartridges with a 12-ft. wooden tamping pole. On this job it takes 3 lb. of explosives to break 1 cu. yd. of material.

Once the wiring has been completed, the face is cleared of the blasting crew and the powder train is moved out of the tunnel. Detonation is made with a direct 440-volt line mounted on the left side of the tunnel away from the normal lighting wires. The 440 line is wired to a shooting switch 800 to 1,000 yd. from the heading. When the heading has been checked for workmen, the walker connects the first section of the safety line. As the walker makes his way to the shooting switch, he again checks the tunnel for stragglers. At the 60-amp. switch, the line is connected. The line is equipped with a safety switch which is connected just before detonation, then disconnected after the blast is made.

Mucking

In the majority of shots, this system pulverizes rock sufficiently for immediate mucking. In rare stretches of harder rock, it has been necessary to plug boulders. These have often had holes in them, making them easy to load and reshoot.

Once the heading is blasted, a #100 Conway mucker moves past the jumbo to the facing. A line of 10-yd. dump cars is pushed into position by one of the several Plymouth engines on the job. The empty cars move past the jumbo to the rear of the mucker, where they are loaded by a conveyor belt. As a car is filled, the Diesel pulls the full car back to the jumbo where it is lifted above the track. The Diesel then pushes the next empty to the mucker, unhooks, and waits until the jumbo



FIRING SWITCH: Only after the blasting crew has reached a place of safety, and the entire distance between the face and the firing switch has been checked for stragglers is the final connection made in the blasting circuit. The firing switch is at least 800 yd. from the face.

LAYING TRACK: A factor in the excellent progress being made is the speed with which mucking and drilling equipment is able to return to the face and work. Laying track as soon as the face clears after a blast aids in getting this equipment in working position quickly.

drops the full car behind the forward empty cars. The process is repeated until the cars are filled or until the facing has been thoroughly mucked. The rail cars are then hauled outside the tunnel to the banks of the Trinity where they are emptied. It is not necessary to fill in an exact area since the entire fill depot will be under many feet of water.

With the face clear, crews move in once again. They carry the steel supports to the face, move them into position. Simultaneous with this, other sections of the crew are laying rails to the new face so that the jumbo and muckers can move in. When the jumbo is moved in, the steel supports are swung into position and bolted at the top.

But, before the jumbo can move toward the new heading, tunnel crews must lay two sections of rail. A California switch is carried about 600 ft. from the heading, and is moved into a new position whenever necessary. There are run-arounds every 4,000 yd. to speed up two-way train traffic, since trains pass in and out of the tunnel regularly with lumber, steel supports, explosives, and special equipment.

SKM uses 36-in. 60-lb. mainline and an 8-ft. 2-in. gantry rail for the jumbo. The gantry is kept within 30 ft. of the facing at all times. The mucker rides on the mainline and is towed back to the switch when it is not in actual use.

When both rail systems are in position and the crews have connected the supports, they add whatever auxiliary boarding may be necessary. They are then ready for a new cycle.

Little Water Encountered

Maintenance in the tunnel is both easy and fast. There is very little water; however, when water does collect, it is pumped away from the face into troughs along the side of the tunnel where it can flow out of the hole and into the Trinity. In cases where the water affects the mainline track a shovel crew moves in, channels the water away from the track, and blows the surface dry with an air gun. Constant maintenance is the rule on the mainline, and all rail equipment, the mucker, and the jumbo receive regular lubrications. The rail equipment is maintained in the rail shop, a quarter of a mile from the tunnel, but the mucker and jumbos are lubricated in the tunnel.

When the work began, the excavation was mushrooming on four headings: the outlet, the adit downstream, the adit upstream, and the inlet. Now that crews have made good headway the work has been dropped to two headings. These work three shifts, six days a week. There are two separate offices for these crews, with headquarters for each close to tunnel ends.

Personnel

The work is under the direct supervision of John Shea, project manager. His offices are in Whiskeytown. Harry Greshuk is inlet superintendent and Mike Royce is outlet superintendent. Glen Meers is project engineer; Jim Springer is electrical superintendent; Lee Garett, mechanical superintendent; and Jack Garner is the main office manager at Alhambra, California. Roger Williams is field office manager at Whiskeytown.

Work on the tunnel is now more than half of the way through the Buckhorn Mountains. When it is finished, it will play an integral part in another step forward for the West.

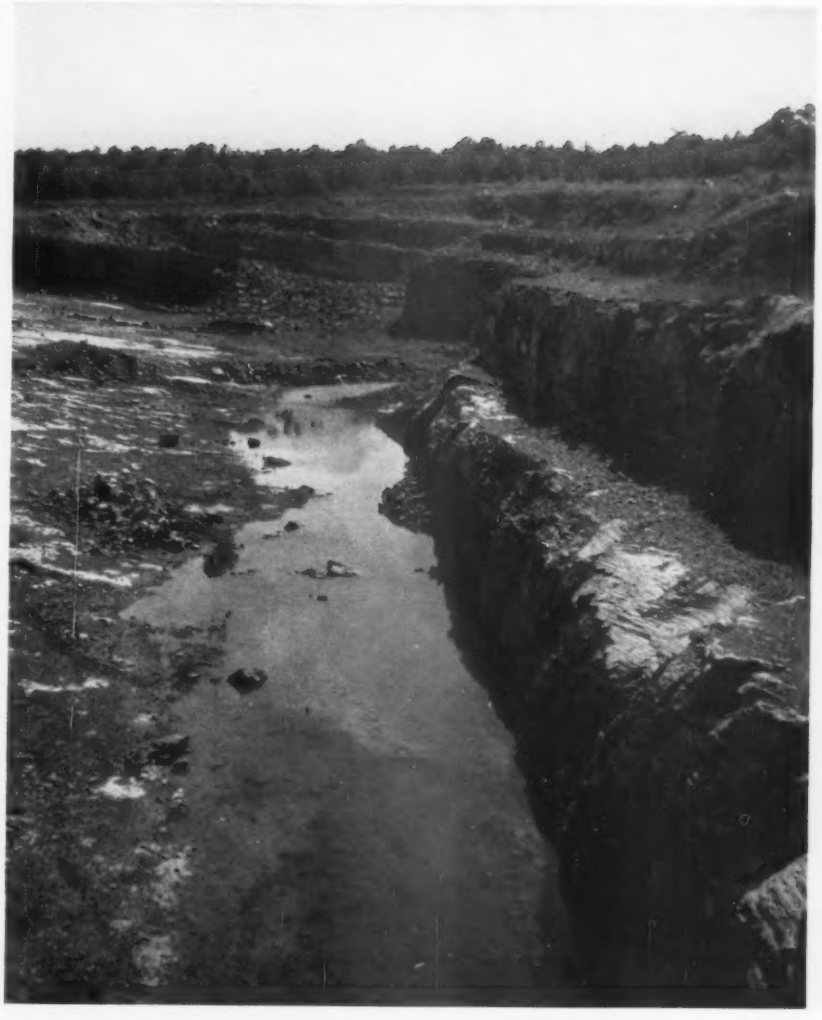
TRANSPORTING EXPLOSIVES: The primed dynamite cartridges are transported to the working face in a specially designed and constructed powder car which will protect its cargo during transit from the powder magazine.

Blasting with Short-Period Delay Detonators In Georgia Limestone

An outline of the blasting technique of Ready-Mix Concrete Company, which produces well-broken rock and a minimum of vibrations

JOHN W. LOVIZA*

A short distance beyond the city limits of Rome, Georgia, are the vast operations of the Ready-Mix Concrete Company. It was no mere chance that this 55-acre property was selected, for it was only after extensive exploratory core drilling and testing throughout the Rome area that the officials of Ready-Mix decided this site was the proper location for their operations. The tests showed the area abounded in limestone of an excellent quality, with physical and chemical properties making it suitable for a variety of uses. Another important factor that helped swing the decision to this site was the availability of adequate transportation. It is served by the Central of Georgia Railroad, which means that freight shipments can easily be made to distant customers; at the same time good paved roads, adjacent to the property,



THE QUARRY FACE: The height of the face ranges from 58 to 63 ft. Quarrying operations are carried on three benches: the top level is 15 ft. high, the middle is 18 ft., while the low bench is from 20 to 25 ft. in height.

*Hercules Powder Company
Birmingham, Alabama

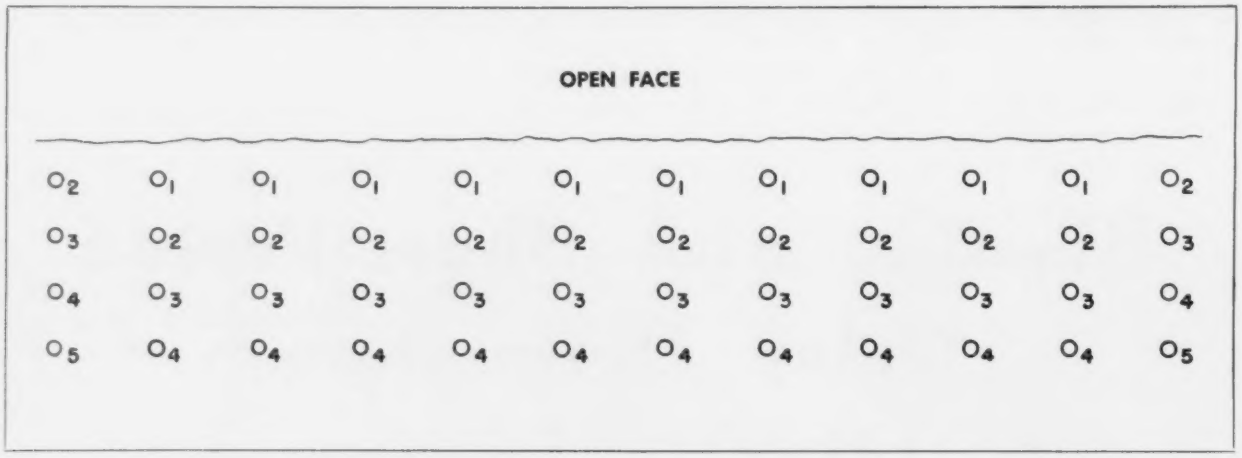

OPEN FACE
O2 O1 O1 O1 O1 O1 O1 O1 O1 O1 O1 O2
O3 O2 O2 O2 O2 O2 O2 O2 O2 O2 O2 O3
O4 O3 O3 O3 O3 O3 O3 O3 O3 O3 O3 O4
O5 O4 O4 O4 O4 O4 O4 O4 O4 O4 O4 O5

FIGURE 1: This diagram shows the layout of a typical 48-hole blast at the Ready-Mix quarry. The numbers alongside the holes indicate the order of firing. Holes are spaced on 9-ft. centers, and each hole carried a 5-ft. burden.

QUARRY AREA: Although the area where blasting is now carried on is more than ½ mile from the nearest habitation, great efforts are made to keep vibrations to a minimum. The low-bench blast shown was detonated by short-period delay electric blasting caps.

EASY DIGGING: The operator of the Koehring shovel finds the rock well broken and easy to handle with the 1½-cu. yd. dipper.

facilitate truck deliveries to Rome and nearby municipalities. Last but far from the least consideration was that the quarry would be over ½ mile away from any housing so that complaints about vibration and noise would be kept to a minimum.

The primary product of the Ready-Mix Concrete Company is crushed limestone, which is sold in various sizes and gradations for use as concrete, asphalt aggregate, riprap, and railroad ballast. Since the start of operations at the property eight years ago, over 1,700,000 tons of stone have been removed from the quarry.

The average height of the quarry face is 60 ft. and varies not more than 5 ft. from this figure. The limestone formation now being quarried lies on approximately a 20° pitch. Quarrying operations are being carried on by the terrace or bench method. Three benches are being worked: the top bench is 15 ft. high, the second or middle bench is 18 ft. high, while the lower bench ranges from 25 to 30 ft.

Short-Period Delay Firing

Shortly after Ready-Mix began operations at this location the newly developed short-period, or millisecond, delay blasting came into use. After extensive experiments with this new procedure, Ready-Mix was one of the first companies to adapt this system of blasting to its operations. Company officials found that the interval between each delay period resulted in a few holes or a small amount of explosives being detonated at any one instant. This greatly reduced vibrations and, because the rock was not being shot against the solid as each hole was fired, fragmentation was improved. In addition, endbreak and backbreak were reduced. Ready-Mix estimates that with short-period delay electric blasting caps only about 20 to 25% of the explosives loaded in a typical blast is being detonated at one time.

The drilling equipment at Ready-Mix quarry consists of three wagon drills using 1¼-in. drill steel fitted with 2¼-in. bits. The wear on the bit steel is not too severe and only normal bit replacement is required. Compressed air to power the drills is supplied by a Gardner-Denver 600-c.f.m. compressor. This equipment is sufficient for all

the drilling requirements except during periods of unusual demand for Ready-Mix products. When this occurs, a Joy 500 fitted with a 4-in. bit is brought in to drill sufficient holes for one or two blasts.

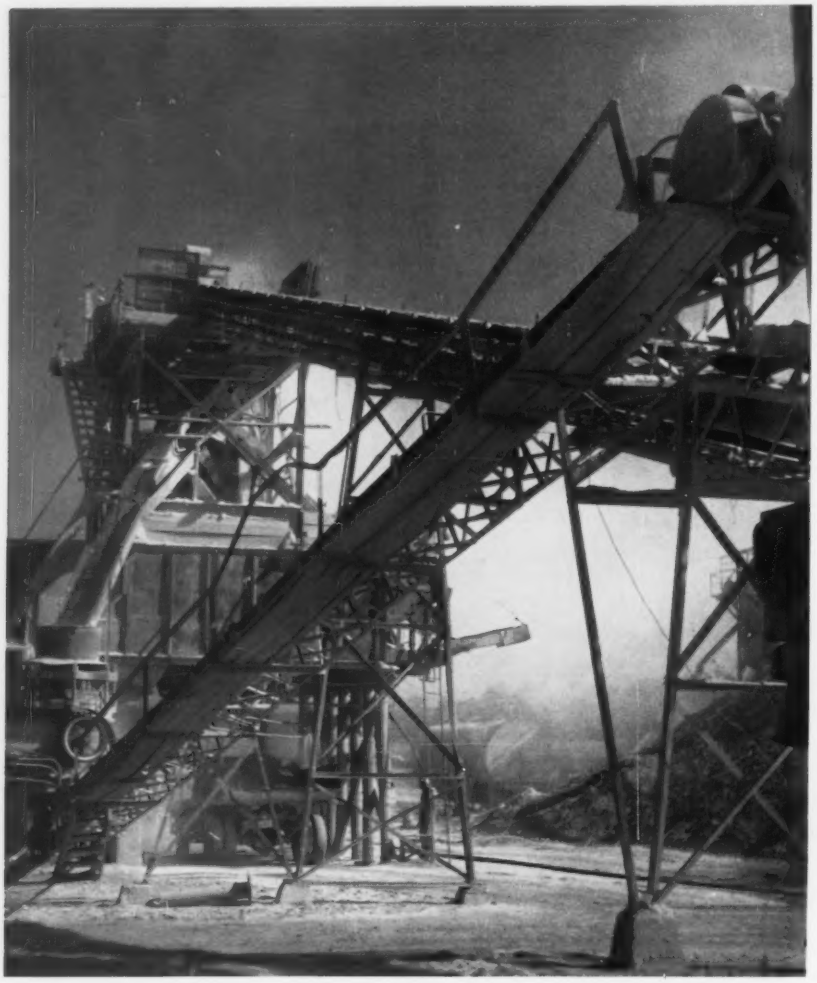
Drilling and Loading

When operating on the middle bench, which is 18 ft. high, using the Joy wagon drill with a 2¼-in. bit, a typical blast will consist of four or five rows of holes each containing 12 holes. The holes are loaded with Gelamite® 1 1¼ by 24-in. cartridges. The holes are loaded solid until the charge is within 5 ft. of the surface. The remaining bore hole is stemmed to the collar with drill cuttings. Holes are spaced on 9-ft. centers, and each hole has a burden of 5 ft. Holes contain approximately 16.8 lb. of Gelamite 1, which gives a loading factor of 0.56 lb. of explosives per cu. yd. of rock in the solid, or about 4.0 tons per lb.

The firing pattern, using No Vent® Short-Period Electric Blasting Caps, has been standardized for all blasts. The center section of each row is fired one period sooner than the end holes of the row. This pattern is illustrated in Figure 1 on page 180. The primer cartridges are placed in the bottom of the holes.

Naturally, a slightly different drilling and loading procedure is used when the Joy 500 drill moves into the working area. The 4-in. holes are spaced on 12-ft. centers, and each hole has a burden of approximately 10 ft. The 18-ft.-deep holes will each contain 44.0 lb. of Gelamite 1 packed in 3 by 24-in. cartridges. This amount of explosives will occupy about 11 ft. of the drill hole, the remaining 7 ft. being stemmed with drill cuttings. This method of loading produces approximately 4.0 tons of rock per lb. of explosives, making a powder factor of 0.55 lb. per cu. yd. of rock in the solid.

The blasting technique in use at Ready-Mix consistently produces excellent breakage, with the stone being moved out from the face without excessive throw and with very little secondary blasting necessary. A Koehring shovel with a 1½-cu. yd. dipper loads the blasted rock into Model 36 FD Euclid trucks of 9-cu. yd. capacity for transportation to the 25 by 36-in. Telsmith primary crusher where the stone undergoes further processing.



CONVEYOR SYSTEM: Here the rock from the primary is conveyed to the secondary crusher for additional preparations. Almost any commercial-size stone can be supplied.

Vibration Studies

Being conscious of the company's responsibility to be good neighbors in the community, A. W. Ledbetter, Sr., president of Ready-Mix, has long been aware of the potentially unpleasant situations that might arise from complaints about vibrations and noises from blasting operations. In an effort to evaluate the noise and vibration levels, Mr. Ledbetter retained Harold H. White, a consulting engineer of Joplin, Missouri, who specializes in the problems of vibrations, air-blast pressures, and noise incident to blasting operations.

In Mr. White's study over an extended period, the most modern equipment was used. For the vibration evaluation, Mr. White used a Leet three-component seismograph to measure the ground deflection and a General Radio Corporation air-pressure meter to determine the intensity of the air pressure or concussion at the time of or after the blast. Another piece of scientific equipment which Mr. White used in his work was the recently developed Electronic-Vibration Comparascope. This instrument shows vibrations as they occur and is a visual means of comparing vibrations from various causes. The scope of the sensi-

STORAGE BINS: Ready-Mix has unique bins for the storage of stone before delivery to trucks. Two bottom-dump coal cars mounted on strong pilings facilitate the loading of trucks for local delivery.

tivity of this instrument ranges from the vibrations caused by natural earth movement to motion from sources unconnected with blasting operations. The completed study showed that vibrations resulting from blasting operations as carried on by Ready-Mix at its Rome location were well within normal tolerances, and that the possibilities of vibration damage to homes and buildings surrounding the property were extremely remote.

In addition to A. W. Ledbetter, Sr., who as president heads Ready-Mix Concrete Company's progressive management, other officials are: A. W. Ledbetter, Jr., vice president; A. M. Carter, vice president; Paul E. Cole, quarry superintendent; and George Messer, Jr., quarry foreman.

IN CHARGE: Much of the responsibility for the smooth operation of the Ready-Mix Concrete Company quarry rests on the sturdy shoulders of George Messer, Jr., quarry foreman, and A. W. Ledbetter, Jr., vice president.

JAMES F. ARMSTRONG

JOHN BRUCE BONNY

THE MOLES AWARDS

James F. Armstrong and John Bruce Bonny to receive bronze plaques and citations for outstanding contributions to construction progress

THE Awards committee of The Moles, an association of prominent executives in the tunneling, dam-building, and heavy-construction industry, recently announced that James F. Armstrong of New York City and John Bruce Bonny of Boise, Idaho, will receive The Moles Awards for 1959.

The awards, made annually to one member and one nonmember of the association, are bronze plaques and citations. These are given for outstanding contributions to construction progress, and "are considered the highest recognition that can be awarded individuals for service to the construction industry," stated Howard A. Collins, president of The Moles, in making announcement of the Awards committee selections. Formal presentations of the honors will be made at the Moles Award dinner on January 28, 1959, at the Waldorf-Astoria Hotel in New York City. Mr. Armstrong and Mr. Bonny are the nineteenth pair of honorees to receive the award. Some of the previous winners are former President Herbert Hoover, Robert Moses, Admiral Ben Moreell, Peter Kiewit, Harvey Slocum, and Louis Perini.

James F. Armstrong

James F. Armstrong, the member winner, is vice president of the Peter F. Connolly Company, and has been identified with heavy construction for more than a half-century. A great deal of his work has been in driving tunnels, in bridge construction, and, more recently, in the highly specialized field of pneumatic caissons for bridge foundations. Mr. Armstrong is a life member of the American Society of Civil Engineers.

John Bruce Bonny

John Bruce Bonny, the nonmember winner, is vice president and general manager of Morrison-Knudsen Company, Inc., and directs the world-wide operations of this heavy-construction organization. During 1958, M-K had more than 200 separate contracts in the United States and 18 foreign countries. Mr. Bonny is a graduate of the University of California, and has spent his entire professional career in the construction field.

Winning Miners and Quarrymen Awarded Sentinels of Safety Trophy

Elaborate ceremonies impress employes with importance of safety program

SENTINELS OF SAFETY trophy and flag presentations were made recently in impressive ceremonies at the mines and quarries for the winners of the 1957 National Safety Competition. The winning symbols were presented at five of the six winning plants; at the sixth, no formal presentation was made because the Pine Knot Colliery of the Reading Anthracite Company at Minersville, Pennsylvania, had been closed since the winning of the award in the anthracite group.

Apparent were the definite efforts by the plants' managements to make the presentation ceremonies of lasting value to the employes in promoting the cause of safety for the future. This aim was achieved in a number of ways. Often, top officers from the companies' home offices congratulated the miners. Addresses by company men stressed the importance that management attached to safety, the time, attention, and money they were willing to devote to improve safety programs, to eliminate hazards, and to instill an awareness of safety in the minds of employes.

The Bellefonte Mine

Miners of the Bellefonte, Pennsylvania, Mine of the National Gypsum Company gathered at the Penn Belle Hotel in Bellefonte on August 16 at noon for the presentation of the National Safety Competition award in the nonmetallic classification. Harold Gustafson, plant manager, was master of ceremonies for the meeting of approximately 150 employes.

John A. Johnson, chief of the Bureau of Safety of the United States Bureau of Mines, presented a Certificate of Accomplishment in Safety to each miner. "The Bellefonte Mine has been entered in the National Safety Competition for the past nine years," Mr. Johnson said. "In this nine-year period your frequency rate has been 6.05, which is about one-third the rate of the other nonmetallic mines."

Richard E. Gill, production man-

AT THE BELLEFONTE MINE CEREMONY: Gilbert B. Eckley, representing the employes of the Bellefonte Mine of the National Gypsum Company, receives the Sentinels of Safety trophy from Thomas E. Miller, contributing editor, The Explosives Engineer. At the left is John A. Johnson, chief of the Bureau of Safety of the United States Bureau of Mines; at right is Harold Gustafson, plant manager.

ager of the National Gypsum Company at Buffalo, New York, said the company's recent purchase of additional stone property adjacent to the mine, greatly extending its life, signified the company's confidence in the outstanding safety record the men had achieved.

Thomas E. Miller, representing THE EXPLOSIVES ENGINEER, presented the Sentinels of Safety trophy to Gilbert B. Eckley, and the Sentinels of Safety flag to Joe Pinto, both representing the Bellefonte employes.

Merrill Pollard, director of safety of National Gypsum, Buffalo, New York, and Victor H. Thomas, vice president of the United Cement, Lime, and Gypsum Workers International Union, congratulated the men on their safety achievement during 1957.

Michigan Limestone's Calcite Quarry

The Michigan Limestone Division Quarry of United States Steel Corporation, at Rogers City, Michigan, held the presentation ceremony for its Calcite Plant winners on August 27 at the change of shifts. L. J. Patterson, manager of operations, Northern District, was master of ceremonies.

Donald T. Van Zandt, manager of the Calcite Plant, accepted the trophy from Mr. Miller, saying, "We have not one safety director, but many," and explained that the winning of the award meant much work for many among the employes.

Allen D. Look, district supervisor of health and safety of the U. S. Bureau of Mines, Duluth, Minnesota, presented the individual Certificates of Accomplishment. "Any safety achievement is the result of many individual efforts," Mr. Look said. "These many efforts have won for you the highest safety award that can be given. Had any single man suffered a disabling injury last year, we would be presenting this award to another quarry."

Christian F. Beukema, president of the Michigan Limestone Division, said he was "filled with pleasure and humility to witness an award being given to this plant. It is an honor you richly deserve. The slogan 'Safety First' was coined by U. S. Steel." He voiced management's determination to encourage a safety awareness among its employes at the quarry.

The Mississippi Group Mine

Wives and children accompanied the open-pit winners to the ceremony held by the Hanna Ore Mining Company for the Mississippi Group Mine employes at Keewatin, Minnesota, on October 3 at 3 p.m. George A. Borgeson, manager of safety and claims, was chairman of the meeting. R. W. Whitney, vice president and general manager of mines of the M. A. Hanna Company, Cleveland, told the miners and their families that if they maintained a respect for the hazards of the mine, accidents will not happen. "We impress upon our children the hazards of the highway, of crossing the street," he said, adding that they must impress upon themselves the same sort of message.

R. M. Gross, superintendent of the

THE QUARRY AWARD: Allen D. Look, supervisor of health and safety, U. S. Bureau of Mines, Duluth, Minnesota, presenting the individual Certificates of Accomplishment in Safety to Robert Bruning, representing the employes of Michigan Limestone Division's Calcite Plant, winners of the quarry award. In background are H. C. Farrell, director of industrial relations, and Donald T. Van Zandt, manager Calcite Plant, Mr. Miller, Christian F. Beukema, division president, and L. J. Patterson, district manager of operations.

Mississippi Group Mine, received the trophy from Mr. Miller, and Willard Anderson, president of United Steel Workers Local 2660, received the flag. Addressing the wives and children of the miners directly, Mr. Gross said it was "wonderful that husbands and fathers can earn a livelihood for you without suffering injuries," and asked their help in promoting safety in the home. Mr. Johnson of the Bureau of Mines presented the individual Certifi-

MINER'S FAMILY: Mr. and Mrs. Charles Lindberg and son, Chuckie, study the Sentinels of Safety trophy presented to the Mississippi Group Mine of Hanna Ore Mining Company, Keewatin, Minnesota, at presentation ceremonies for miners and their wives and children.

CALLOWAY-MARY WINNERS: Presentation ceremony held at Calloway "B" shaft of Calloway-Mary Mine of Tennessee Copper Company Division, Tennessee Corporation, Ducktown, Tennessee, October 8.

cates of Accomplishment to the men, and Mr. Look presented the Joseph A. Holmes Certificate of Honor to John Russo, general pit foreman.

Bert M. Andreas, manager of Minnesota Mines, Joe Gustin, representing the United Steel Workers, and Bernard G. Hurley, Itasca County mine inspector, also addressed the meeting. Refreshments were served to the employes and their families following the ceremony.

The Calloway-Mary Mine

Tennessee Copper Company Division of the Tennessee Corporation held its presentation ceremonies on October 8 at 2:30 p.m. at the Calloway "B" shaft of the Calloway-Mary Mine, Ducktown, Tennessee. H. F. Kendall, superintendent of mines, was chairman of the meeting. M. C. McCall, representing the United States Bureau of Mines, Birmingham, Alabama, Office, congratulated the winners in the metal mine group on their achievement, and presented the individual Certificates of Accomplishment.

Mr. Miller, representing THE EXPLOSIVES ENGINEER, presented the Sentinels of Safety trophy and flag to the miners. He pointed out that the Calloway-Mary Mine either has won the trophy or received honorable mention in seven of the 14 years the mine has been entered in the competition.

The Republic Mine

The Republic Steel Corporation held its award ceremony for the Republic Mine, winners in the bituminous-coal mine group, on November 1, 1958, at the Pikeville College Gymnasium, Pikeville, Kentucky. J. N. Hedding, manager of northern coal mines, was master of ceremonies, and C. C. Virgin, superintendent of industrial relations, was chairman of the meeting. E. R. Johnson, vice president in charge of operations, and E. B. Winning, assistant vice president in charge of operations, addressed the miners and their wives and children. R. H. Ferguson, assistant director of industrial relations, presented the Republic award pins to Kermit Adkins, chairman of the Republic Safety Committee. R. D. Reeder, U. S. Bureau of Mines, presented the individual Certificates of Accomplishment to Fred Belcher, Jr., president of Local Union No. 8045, United Mine Workers.

J. L. Coyer, superintendent of the Republic Mine, accepted the Sentinels of Safety trophy and flag from Mr. Miller. Following the presentation Mr. Coyer was given a surprise award, a plaque from the Kentucky Department of Mines and Minerals. This award of merit was made to Mr. Coyer "in recognition of devoted service to his fellow men, and untiring efforts toward promoting safety in the coal industry."

The five ceremonies were marked by an excellent spirit of cooperation among the men, the company managements, and the union officials, making it apparent that on the happy occasion of a safety presentation all elements agree upon the importance of safety in operations. The trophies and flags are provided each year by THE EXPLOSIVES ENGINEER.

SURPRISE AWARD: James Phalan (right), chief deputy of Mines and Mineral Industries, presenting award of the Kentucky Department of Mines and Minerals to J. L. Coyer, superintendent of Republic Mine, "in recognition of devoted service to his fellow men and untiring efforts toward promoting safety."

Mineral Prospecting in Montana

J. L. PEIRSOL*

A crawler-mounted drill was perched
Along a ledge of rock-strewn shale.
The drilling operators searched
For minerals in biting gale.
Montana hit a "ten below"
Accompanied by a falling snow.

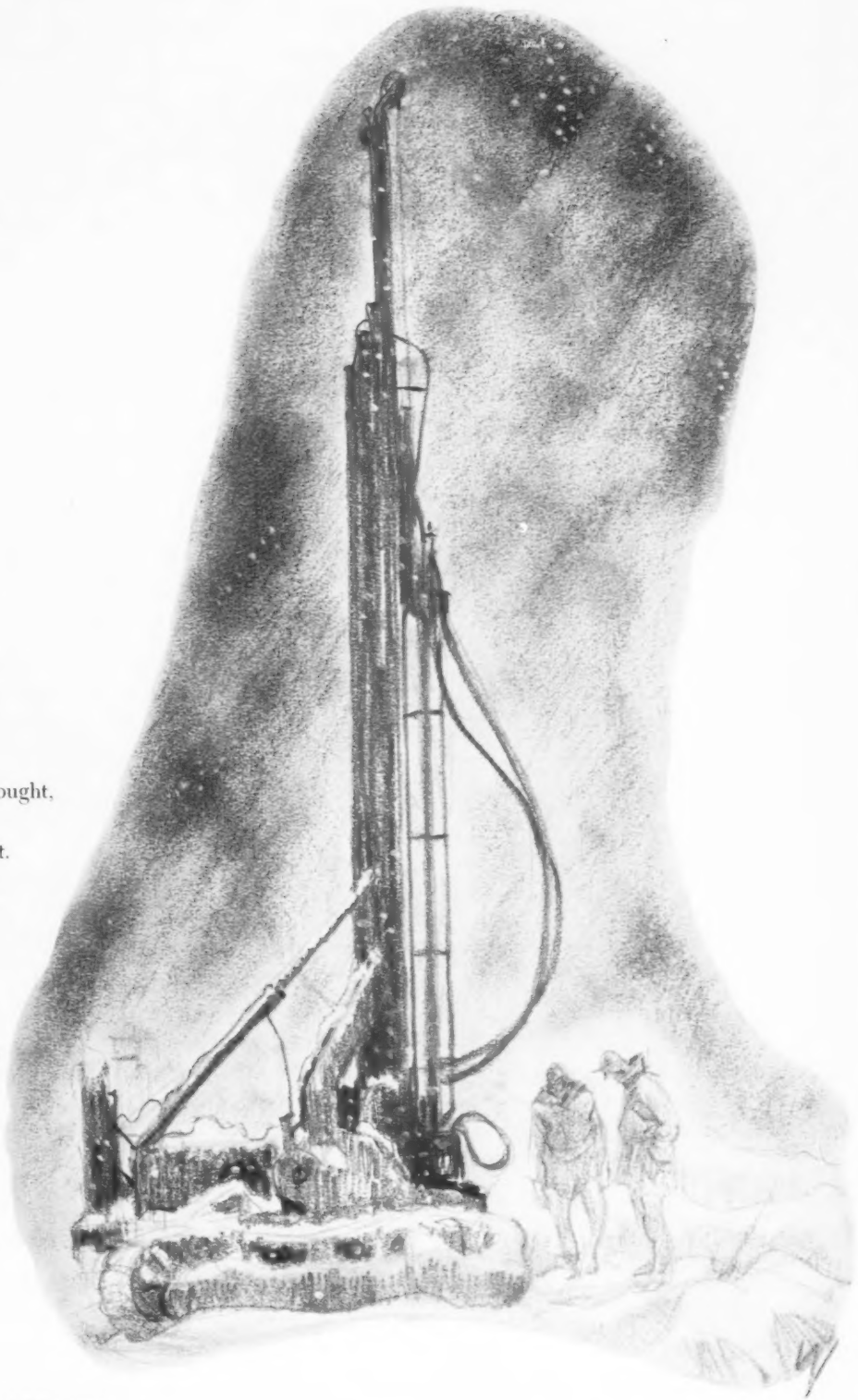
With guy lines white with icy frost,
The drilling bit smashed hard rock bed.
Tired drillers found their tools were lost—
A fishing job lay just ahead.
They got out fishing tools to clasp
The tools sunken beyond their grasp.

The wind blew hard, a cruel, cold blow;
Chilled drillers turned their collars up
As ice was mingled with the snow.
Each drained a steaming coffee cup,
Then fished for tools for quite awhile,
Their faces stern, bereft of smile.

At last the fishing tools caught hold;
They pulled the drill tools from the hole
Untouched by yellow placer gold,
The object of their search and goal.
Discouraged, they replaced their tools,
And cursed themselves for being fools.

"At ten below" who cares for GOLD?
Their frost-numbed minds held fast this thought,
As many cigarettes were rolled
With wind-swept flame, they finally caught.
Then, with a will they tried again
To find this gold treasured by men.

"We might as well give up," one said,
"It's gittin' on toward dark, you know."
The other driller shook his head,
While drill tools jerked and tugged below.
With joyful cry, they each grasped hold
The drill, at last, struck PLACER GOLD.



*1409 Fifth Avenue
Beaver Falls, Pennsylvania

NEWS NOTES

NEW CRANE BULLETIN

The complete range of Koehring rubber-mounted cranes, from 15 to 45-ton lift capacity, is presented in a new 4-page bulletin just released. Printed in two colors, the bulletin shows a total of 11 photos of the highly mobile equipment, with important commentary on each size crane.

Illustrated are 15-, 25-, 35-, and 45-ton lift-capacity truck cranes. Also included are photos of the 15- and the new 25-ton lift-capacity "Cruiser" cranes. The manufacturer states that all models are convertible for dragline, clamshell, or bucket work. Copies of the bulletin can be obtained from Koehring Division, 3026 West Concordia Avenue, Milwaukee 16, Wisconsin, or from distributors.

INSULATED CABLE HANDBOOK

To help civil and consulting engineers and contractors of the heavy-construction industry prepare their specifications for special electric cable installations, a new, comprehensive book on "NEPCO-SIL" silicone rubber-insulated cables has just been published by National Electric Products Corporation, Pittsburgh.

Discussed in separate sections of the new book are individual specifying factors including performance data, service life, physical properties, electrical characteristics, suggested applications, and test results. Charts and photographs illustrate comparative service life and performance of organic and silicone rubbers within a temperature range of —55 degrees Centigrade to 200 degrees Centigrade. Electrical characteristics are reflected in table form. The table provides comparison with other insulating materials according to the per cent of power factor, specific inductive capacitance and constant versus water soak at 70 degrees Centigrade. ASTM specifications and typical properties of NEPCO-SIL insulation are also listed.

The new handbook can be obtained by writing to the Advertising Department, National Electric Products Corporation, 2 Gateway Center, Pittsburgh 22, Pennsylvania.

NAYLOR PIPE CATALOG

As a help to pipe users, Naylor Pipe Company, Chicago, has just published a condensed catalog covering the complete line of the company's pipe, fittings, flanges, and connections.

Data presented include standard specifications for Naylor Lockseam Spiralweld pipe in sizes from 4 to 30 in. in diameter; illustrated data on Naylor one-piece Wedgelock couplings and other types of connections; standard Naylor fittings for lightweight pipe; and welding flanges for Naylor pipe.

In addition, ordering information and applications in diversified industries are presented in concise form.

Copies of the condensed catalog, known as Bulletin No. 59, can be obtained from Naylor Pipe Company, 1230 East 92nd Street, Chicago 19, Illinois.

CATERPILLAR BOOKLET

Caterpillar Tractor Co. has released a new booklet, "Breaking the Barriers to Profit," designed to aid in machinery selection for the sand and stone industries.

Containing on-the-job photos of Caterpillar-built machinery at work throughout the country, the booklet shows how today's modern earthmoving equipment handles the many production tasks around the pit site. According to the manufacturer, reports from actual operations explain how Cat-made equipment offers a saving in equipment working expenses. Copies of the booklet "Breaking the Barriers to Profit" may be obtained from Caterpillar dealers or by requesting Form D850 from the Advertising Division, Caterpillar Tractor Co., Peoria, Illinois.

REVISED SWITCH CATALOG

Newly revised Catalog 83c, covering a complete line of industrial enclosed switches, has just been released by MICRO SWITCH, Freeport, Illinois, a division of Minneapolis-Honeywell Regulator Co.

This catalog gives complete details of nine housing groups of metal-enclosed switches for industrial uses. Explosion-proof, maintained-contact, prewired, hand-operated and sealed switches are a few of the 99 different listings shown.

The new 20-page catalog is published as an aid to the plant engineer and maintenance man, as well as the designer of original equipment. Copies may be secured by writing direct to the company.

LIMA GEARMOTORS

The Lima Electric Motor Co., Inc., has announced the addition of Vertical Gearmotors to its line of electric motors and speed reducers. These new units are available with either flanged mounting face, or with standard vertical extended housing. They are supplied in double or triple reduction units with Duti-Rated Lifetime gearing, in ratings from 1 to 75 hp., with reductions from 350 to 7½ r.p.m.

Built with standard LIMA motors in drip-proof, totally enclosed, fan-cooled or explosion-proof enclosures, these units operate at normal torque, on 3 or 2 phase, 60 cycle, 208, 220/440, or 550 volts. Special voltages and frequencies as well as mechanical modifications are also available.

For complete information, write The Lima Electric Motor Co., Inc., Lima, Ohio.

JOY BELT BULLETIN

Belt conveyors that go around corners are described in Joy Manufacturing Company's new four-page bulletin LD-109. Operation of the Joy 90° Belt Turn Unit and the "Live Belt Reserve" system of conveyor advance is explained.

Through photographs, a mine plan, and text, the manufacturer claims that Belt Turns in an extensible conveyor system give continuous mining new flexibility and save costs. A section on "Live Belt Reserve" tells how Belt Turns and special mobile pulleys permit storage of large quantities of belting in live reserve to enable face equipment to advance for an entire shift without stopping to add more belt.

For more information, write Joy Manufacturing Co., Oliver Bldg., Pittsburgh 22, Pennsylvania.

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XR57-3

HERCULES

50-Rs Speed Mountain Top Removal At Huge Latin American Copper Mine

Fast-drilling Bucyrus-Erie rotary drills were put to use recently as Southern Peru Copper Corporation began blasting operations at its new mine located 100 miles inland from the Pacific port town of Ilo.

Before any ore can be mined, the company must remove the top from a mountain called Toquepala. Excavation amounts to some 120 million tons of rock and earth.

To get things going, seven 50-Rs were brought in for drilling blast holes. They are well equipped for the job. *Variable drilling speed* and *variable pulldown pressure* provide the resources for speedy drilling at Toquepala.

Ward Leonard variable voltage control gives the operator smooth, instant command over rotation of the drill pipe. He can choose the most efficient speed for a given formation without stopping the drilling operation. Hydraulically powered down pressure on the bit provides controlled load on drilling tools for maximum penetration.

These seven 50-Rs are electric rigs designed for drilling 9⅞ to 12¼-in. holes. For drilling 6¾ to 9-in. holes Bucyrus-Erie Company offers the 40-R with either diesel-electric or full electric power.

Get the full story on these drills today. Write direct for illustrated literature. Bucyrus-Erie Company, South Milwaukee, Wisconsin.

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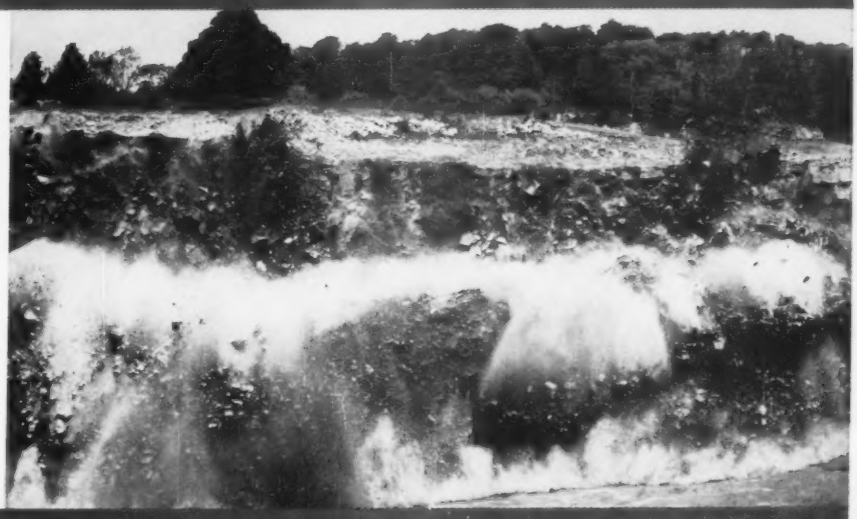

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XR58-2

In secondary blasting, it's easier to connect and ignite all safety fuse with *Quarrycord*

Prime with safety fuse and blasting caps. You'll play-it-safe two ways:

- No danger from stray electrical currents or thunderstorms.
- No big "boom!": you get a series of small shots: "pop-pop-pop".

Connect and ignite your safety fuse primers with Quarrycord and play-it-safe *again* because—

- No men on the rock pile. The entire blast is set off by *one* man at a point where escape is safe and easy.

Quarrycord is packed on spools in 100-ft. lengths. It is easily lighted with a match and burns with a very hot open flame at the rate of about one foot per second.

HOW TO USE QUARRYCORD

Cut your safety fuse in equal lengths as prescribed by your State law, and prepare your primer cartridges. On the end of the fuse opposite the blasting cap place a Connector. This is a metal tube containing an ignition compound in the slotted end, and color-banded for easy identification. Load and tamp the holes.

When ready to blast, connect all holes with Quarrycord, placing it in the slot of each Connector and pressing the "lid" down to hold the Quarrycord firmly in place and assist ignition.

Connect your main lines with cross lines wherever these will cut down the over-all burning time. Lead main lines off to a point away from the rock pile. When all is ready, light this end with a match and go to a place of safety. Q-4

It's quite a story, told completely in this folder which we'll send you, free, when you ask for it. Write today.

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